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TITLE

POROUS BODY AND METHOD FOR PRODUCING THE SAME

FIELD OF THE INVENTION

The present invention relates to a porous body useful for a filter, a sound-deadening material, and the like, and a method for producing the same.

BACKGROUND OF THE INVENTION

Conventionally, a variety of porous bodies and methods for producing the same have been known. For instance, Japanese Patent Application Laid-Open No. Hei 7-285412 discloses a cylindrical porous body, which is produced by compressing a material knitted out of fine metal wires by a weaving machine for fine metal wires so that it forms a cylindrical shape, and a method for producing the same. Also, Japanese Patent Application Laid-Open No. 2002-249017 discloses a cylindrical porous body, which is produced by cutting a metal plate into rhombic shapes to form a coil shape, and cutting and winding up the same to form the cylindrical porous bodies, and a method for producing the same (expand processing). Further, in the other case, a porous body produced by generating thousands of holes by foaming a metal and a method for producing the same are known. Furthermore, Japanese Patent Application Laid-Open No. 2002-331235 discloses a porous body produced by foaming and sintering powders of a spherical-shape, and a method for producing the same.

However, the above-listed conventional techniques have problems as will be described below. In the production of the porous body disclosed in the Japanese Patent Application Laid-Open No. Hei 7-285412, there is a limit on the girth of the metal wires weavable by the machine. Therefore, when used under high pressure and aeration, the porous body is unable to resist the high

pressure. Besides, it requires too much time to weave the metal wires, resulting in high production cost. In the production of the porous body disclosed in the Japanese Patent Application Laid-Open No. 2002-249017, there is a problem of requiring many processes in the expand processing, resulting in high production cost. Also, in the production of the porous body produced using a foam metal, there are problems of low pressure resistance and difficulty in low cost production, while exhibiting its capability of producing the porous body of a high quality having fine holes controlled in diameter and length.

Further, the porous body disclosed in the Japanese Patent Application Laid-Open No. 2002-331235 has a problem of low pressure resistance. Furthermore, when producing the porous body by sintering, a process for shaping the outer shape of the porous body into a predetermined shape is required. That means a molding step using a metal mold is required in general and results in high production cost. The sintering without using the mold is conceivable, yet, in that case, there arise problems of slow sintering and low pressure resistance.

On top of this, a technique, which performs sintering after shaping without using the mold and cuts out into a desired shape of the porous body thereafter, is also conceivable.

Notwithstanding the above, in view of the production cost, the cutout process requires higher cost than that of the metal-mold molding process. It is therefore impposible to produce at low cost, leaving a problem. In addition, further improvement in cooling peformance, cleansing peformance, or sound-deadening peformance have been expected.

SUMMARY OF THE INVENTION

The present invention has been made to bring a solution to the above-stated problems. An object of the present invention is to provide a porous body

with high pressure resistance which can be produced at low cost, and a method for producing the same. Another object of the present invention is to provide the porous body with high pressure resistance, cooling capability, cleansing capability, and sound-deadening capability, which can be produced at low cost, and a method for producing the same.

The present invention is a porous body comprising a number of base particles adhering to one another by an adhesion material having a lower melting point than the melting point of said base particle. This enables the base particles to adhere to one another firmly with the adhesion material, so that the porous body with high pressure resistance can be realized at low cost.

Another present invention is a porous body comprising a number of base particles adhering to one another with an adhesion material having a lower melting point than the melting point of said base particle, in which the adhesion material exists on surfaces of the base particles and on boundary faces of the base particles, and a surface area to volume ratio of a space between the base particles is larger than the surface area to volume ratio of the space formed only from the base particles. With such a porous body, it is possible to increase the area that a gas passing through the porous body is caused to touch, so that a cooling capability to cool the gas is improved. Similarly, a trapping ratio of coase particles included in the gas is improved, and whereby a cleansing capability of the porous body is improved. Further, a sound-deadening capability is improved. Furthermore, a pressure resistance capability is improved on the back of the structure realizing mutual firm adhesion of the base particles with the adhesion material.

Still another present invention is the porous body according to the

above-stated inventions, in which a larger amount of the adhesion material adheres to contact portions or most adjacent portions of the base particles which are the surfaces of the base particles exposed in the space formed between the base particles, and a smaller amount of the adhesion material exists on the remaining surfaces as a plurality of island-shaped dots. Based on this, protruding and rececced portions are formed on the surfaces of the base particles from the adhesion material, so that the area that the gas or the like passsing through the porous body is caused to touch is further increased. Besides, the connectivity of the base particles are reinforced. Therefore, the porous body having a well-balanced capabilities of pressure resistance, cooling, cleansing, and sound deadening can be realized.

Still another present invention is the porous body according to the above-stated inventions, in which the adhesion material is a metal. Hence, it is possible to obtain a secure structure in which the adhesion material throughly enters into between the boundary faces of the base particles, so that the pressure resistance capability of the porous body can be improved. Accordingly, the porous body of this structure may be applied to a component of an airbag unit for a vehicle.

Still another present invention is the porous body according to the above-stated invention, in which the base particle is iron and the adhesion material is copper. Hence, when the iron particles being the base particles are heated, the copper disperses on the boundary faces and surfaces of the iron particules as a liquid, so that the surface area is increased by a certain amount corresponding to the protruding and recessed portions formed from the copper or the copper and the iron, as compared to surface area of the porous body composed only of the iron particules. Accordingly, it is possible to improve the pressure resistance capability, the cooling capability, the cleansing capability,

and the sound-deadening capability of the porous body. Moreover, the copper is relatively low cost as a metal material, so that the production cost can be curtailed.

Still another present invention is a method for producing the porous body which includes the steps of: mixing a number of base particles composing the porous body and an adhesion material for causing the base particles to adhere to one another, the adhesion material having a lower melting point than the melting point of the base particle; and heating the mixture, which is obtained by the mixing step, in a state being in a container, in which the base particles are caused to adhere to one another with the adhesion material in the heating step. By adopting such a method for producing the porous body, the porous body with a structure in which the base particles are firmly connected to one another can be obtained at low cost.

Still another present invention is a method for producing the porous body which includes the steps of: coating a number of base particles composing the porous body with an adhesion material having a lower melting point than the melting point of the base particle; and heating composite particles, which are obtained by the coating step, in a state being in a container, in which the base particles are caused to adhere to one another with the adhesion material in the heating step. By adopting such a method for producing the porous body, the composite particles being the base particles having the adhesion material on the surface thereof are obtainable, so that the porous body with a structure in which the base particles are firmly connected to one another can be obtained simply by heating the composite particles. And that, the adhesion material adheres in a particle level, so that the porous body having even conformation can be obtained.

Still another present invention is the method for producing the porous

body according to the above-described invention, in which the coating step is a step for coating surfaces of the base particles with the adhesion material by plating. Hence, the porous body with even conformation can be obtained at low cost.

Still another present invention is the method for producing the porous body according to the above-described inventions, which further includes the step of forming the flat plate obtained after said coating step and said heating step, which are performed to the mixture or the composite particles in a state being in the container, into a cylindrical shape. Hence, one container allows the production of both the porous body of a flat plate and of a cylindrical shape. In addition, the porous body of the cylindrical shape can be produced without using a bottomed sleeve container.

Still another present invention is the method for producing the porous body according to the above-descrived inventions, in which the base particle is iron and the adhesion material is copper. Hence, when the iron particles being the base particles are heated, the copper disperses on the boundary faces and surfaces of the iron particules as a liquid, so that the surface area is increased by a certain amount corresponding to the protruding and recessed portions formed from the copper or the copper and the iron, as compared to surface area of the porous body composed only of the iron particules. Accordingly, it is possible to improve the pressure resistance capability, the cooling capability, the cleansing capability, and the sound-deadening capability of the porous body. Further, the copper is relatively low cost as a metal material, so that the production cost can be curtailed. Furthermore, it is possible to obtain a secure structure in which the adhesion material exhibiting high tenacity enters into throughly between the boundary faces of the base particles, so that the pressure resistance capability of the porous body can be improved. Accordingly, the porous body of this structure may be applied as a component to the airbag unit

for the vehicle. Moreover, both the base particle and adhesion material are metal, so that the composite particles composed of the base particles coated with the adhesion material can be obtained easily by plating.

Still another present invention is a method for producing the porous body which includes the steps of: reducing by heating a number of base particles composing the porous body under a reducing gas atmosphere; brazing surfaces of the base particles with an adhesion material having a lower melting point than the melting point of the base particle; and heating a mixture which is obtained by the brazing step and inputted into a container, in which the base particles are caused to adhere to one another with the adhesion material in the heating step. Basd on this , it is possible to remove an oxide existing on the surface of the base particle, so that the weld is reinforced between the base particles and the adhesion material of the porous body obtained after the heating.

Still another present invention is the method for producing the porous body according to the above-stated invention, in which the container is a container for forming a flat plate, and the method for producing the porous body further includes the step of forming the flat plate obtained after the heating step, which is performed to the mixture in a state being in the container, into a cylindrical shape. Hence, one container allows the production of both the porous body of a flat plate and of a cylindrical shape. In addition, the porous body of the cylindrical shape can be produced without using a bottomed sleeve container.

Still another present invention is the method for producing the porous body according to the above-stated inventions, in which the base particle is iron, the adhesion material is copper, and the reducing atmosphere gas is hydrogen. Hence, when the iron particles being the base particles are heated, the copper disperses on the boundary faces and surfaces of the iron particules as a liquid,

so that the surface area is increased by a certain amount corresponding to the protruding and recessed portions formed from the copper or the copper and the iron, as compared to surface area of the porous body composed only of the iron particules. Accordingly, it is possible to improve the pressure resistance capability, the cooling capability, the cleansing capability, and the sound-deadening capability of the porous body.

According to the present invention, a porous body with high pressure resistance which can be produced at low cost, and a method for producing the same can be provided. Further, according to another present invention, the porous body with high pressure resistance, cooling capability, cleansing capability, and sound-deadening capability, which can be produced at low cost, and a method for producing the same can be provided.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a view showing a container, base particles for a porous body, and an adhesion material to cause the base particles to adhere to one another, which are used for producing the porous body according to a first embodiment of the porous body of the present invention;

Fig. 2 is a view schematically showing a heating unit for heating a container shown in Fig. 1 which has a mixture of the base particles and the adhesion material therein;

Fig. 3 is a flowchart showing a process flow for producing the porous body according to the first embodiment of the porous body of the present invention;

Figs. 4A to 4D are views showing the porous bodies obtained through the production process in Fig. 3, Fig. 4A is the view showing a solid columnar porous body viewing from the above, Fig. 4B is the perspective view showing the porous body shown in Fig. 4A, Fig. 4C is the view showing a cylindrical

porous body viewing from the above, and Fig. 4D is the perspective view showing the porous body shown in Fig. 4C;

Figs. 5A and 5B are views schematically showing a transition of the copper powders, which exist between the iron particles, through the heating step shown in Fig. 3, of which Fig. 5A shows a state before the heating, and Fig. 5B shows a state under the heating in which at almost the center of a space formed from four iron partices, the coppers existing on the surcaces of the upper and lower iron particles are entering into the contact portions of the iron particles;

Fig. 6 is an enlarged view schematically showing the existing state of the iron particles and the copper of the porous body obtained after the cooling step shown in Fig. 3;

Fig. 7A and 7B are views comparatively showing microstructures of the porous body obtained by sintering the iron particles and the porous body obtained through the production process shown in Fig. 3, of which Fig. 7A is the view showing the microstructure of the porous body obtained by sintering the iron particles and Fig. 7B is the view showing the microstructure of the porous body obtained through the production process shown in Fig. 3, respectively;

Fig. 8 is a view illustrating a heating in a second embodiment of the porous body of the present invention, in which a container having therein composite particles composed of the iron particles and the copper is heated in a heating furnance;

Fig. 9 is a flowchart showing a process flow for producing the porous body according to the second embodiment of the porous body of the present invention;

Figs. 10A to 10C are views schematically showing typical composite particles produced through a coating step in the production process shown in

Fig. 9, of which Fig. 10A is a view showing a cross-section of the composite particle which is wholly coated with the copper on the surface thereof, Fig. 10B is a view showing the composite particle which is partially coated with the copper on the surface thereof, and Fig. 10C is a view showing the composite particle which is coated with a small amount of copper dispersed on the surface thereof, respectively;

Fig. 11 is a view schematically showing the microstructure of the porous body obtained by heating the composite particles shown in Fig. 10C after inputting them into the container for forming a flat plate;

Fig. 12 is a view showing the porous body produced by heating and cooling the composite particles shown in Figs 10 after inputting them into the container for producing a flat plate;

Fig. 13 is a view showing a sputter coating apparatus for coating the iron particles with the copper by sputtering, which is another example for producing the porous body according to the second embodiment of the present invention;

Fig. 14 is a view showing an example heating unit for producing the porous body according to the third embodiment of the present invention; and

Fig. 15 is a flowchart showing a process flow for producing the porous body according to the third embodiment of the porous body of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, best modes for carrying out the present invention will be described.

Firstly, description will be given in respect to materials for a porous body used in common in the following respective embodiments. The materials for the porous body are roughly classified into a base particle to compose a

parent body of the porous body and an adhesion material for causing the base particles to ahere to one another. Incidentally, in respective embodiments, for the purpose of describing an adhesion of metals to one another as examples, "welding", which is a subordinate concept of the adhesion, will be used. In the course of a heating step, which is one step of the production process of the porous body, the adhesion material melts and goes into a liquid state to cause the base particles to adhere to one another on boundary faces thereof. This explains why the adhesion material is required to have a lower melting point than that of the base particle as one requirement for the production of the porous body.

In the following respective embodiments, for the base particle, iron particle is used, and for the adhesion material, copper brazing material or a nickel brazing material is used. The iron melts approximately at 1535 °C, the nickel melts approximately at 1450 °C, and the copper melts approximately at 1083 °C. In addition, since the brazing materials are used as adhesion materials, the iron particles can be brazed approximately at 1100 °C to 1150 °C when the copper brazing material (99.9 wt % Cu contained) is used. Meanwhile, when the nickel brazing material (a nickel alloy containing 4 to 5 wt % Si, approximately 3 wt % B, and approximately 10 wt % Cr) is used, the iron particles can be brazed at 925 °C to 1175 °C, which is lower than the melting point of the nickel. Hence, it is possible to produce iron porous body by causing a number of iron particles to adhere to one another with the adhesion material having a lower melting point than that of the iron.

The iron particles used in the present embodiments have 0.5 mm in diameter on average. The copper powders used in the present embodiments have 0.05 mm in diameter on average. However, the sizes of the iron particle and the copper powder are not limited thereto, and the sizes are variable in accordance with usages or production methods of the porous body. Note that

the copper can be provided in various forms such as a powder, a liquid body, and the like.

(First embodiment)

Firstly, a first embodiment of the present invention will be described. The first embodiment is a porous body obtained by a method of mixing and heating iron particles as a base particle and copper brazing material containing copper powders as an adhesion material, and the production method of the same.

In Fig. 1, there are shown a bottomed cylindrical container 1a for producing a solid columnar porous body 10a (refer to Fig. 4A and Fig. 4B) and a bottomed cylindrical sleeve container 1b for producing a cylindrical porous body 10b (refer to Fig. 4C and Fig. 4D) (hereinafter the bottomed cylindrical container 1a and the bottomed cylindrical sleeve container 1b are collectively referred to as container(s) 1).

Here, a production process of the solid columnar porous body 10a and the cylindrical porous body 10b (hereinafter the solid columnar porous body 10a and the cylindrical porous body 10b are collectively referred to as porous bodies 10) according to the first embodiment will be described based on Fig. 3.

The production process of the porous bodies 10 is carried out in order of a mixing step (step S101) for mixing iron particles 2 shown in Fig. 1 as a base particle and copper brazing material containing copper powders 3 which mixed in a liquid flux as an adhesion material, an inputting step (step S102) for inputting the mixture of the iron particles 2 and the copper brazing material containing the copper powders 3 into the container 1, a heating step (step S103) for heating the inputted mixture together with the container 1, and a cooling step (step S104) following the heating.

Alternatively, it is also possible to input the liquid copper brazing material into the container 1 first, and input the iron particles 2 into the

container 1 thereafter. In that case, the production process of the porous bodies 10 starts with the previously-mentioned step S102 as a first step (note: only the liquid copper brazing material mixed in the flux is inputted here) followed sequentially by the inputting step of the iron particles 2, the previously-mentioned heating step (step S103), and the previously-mentioned cooling step (step S 104).

As shown in Fig. 2, the heating step (step S103) and the cooling step (step S104) are carried out by moving the container 1 having the mixture therein in the direction of outline arrows toward a position 1W, a position 1X, a position 1Y, and a position 1Z still on a belt conveyer 5 capable of moving the container 1 through inside a heating furnace 4 (in Fig. 2, the container 1 at each position is denoted by 1 (1W), 1 (1X), 1 (1Y), 1 (1Z)).

In the heating furnace 4 according to the first embodiment, a heating section 4a exists in the vicinity of an inlet and a cooling section 4b exists at an outlet side. The highest temperature of the heating section 4a inside the heating furnace 4 is approximately 1100 °C. This temperature is an appropriate temperature for causing the iron particles 2 to adhere to one another since the copper powders 3 are melted down to be a liquid state at this temperature. Note that the temperature of the heating furnace 4 can be changed adequately depending on kinds of the adhesion materials. Besides, inside the heating furnace 4 is placed under a condition of a reducing atmosphere gas, so that oxide films on surfaces of the iron particles 2 can be reduced.

According to the present embodiment, the belt conveyer 5 is continuously in operation such that the container 1 is heated and then cooled down while moving along with the arrows. However, it is also possible to design such that the content of the container 1 is cooled down by being left as it is by halting the belt conveyer 5 for a predetermined time at the position 1Z in Fig. 2. Further, the heating furnace 4 having no cooling section 4b is also

acceptable. In this case, by moving the container 1 outside the belt conveyer 5 after the heating, the continuous production of the porous bodies 10 is enabled while operating the belt conveyer 5 without the halt.

It should be noted that the outlined portion 11 in Fig. 4D actually has the iron particles 2, whereas, it is outlined for convenience of viewing. However, the porous bodies 10 shown in Fig. 4 are just examples and the porous body can be produced in any form in accordance with the shape of the container 1.

As shown in Fig. 5A, before the heating, the copper powders 3 mixed in the liquid flux exist in spaces between the iron particles 2 while they are still in their power shapes. It should be noted that Fig. 5A omits to illustrate the flux. By mixing the iron particles 2 and the copper brazing material containing the copper powders 3 sufficiently, the copper powders 3 come to exist around the iron particles 2 substantially equally. When heating up the mixture of this state, the copper powders 3 transform from a solid state into a melted state and finally into a liquid state to move into the boundary faces of the copper powders 3, as shown in Fig. 5B. This is caused by a capillary action which is a well-known action frequently arises in brazed portions. Meanwhile, the flux evaporates when heated in the heating section 4a, whereby the flux becomes to a state not to adhere to the surfaces of the iron particles 2.

Incidentally, the same numeral signal “3” will be used for denoting copper materials hereinbelow without regard to the embodiment. As previously mentioned, the liquidized copper 3 causes a kind of capillary action to thereby willingly enter into contact portions (having the smallest spaces) of the iron particles 2. Fig. 5B illustrates a scene where, in the almost center of a space formed by four iron particles 2, the coppers 3 exist on the upper and lower surfaces of the iron particles 2 attempt to enter into the contact portions (or adjacent portions to one another).

As shown in Fig. 6, the melted coppers 3 firmly weld the iron particles 2 to one another by intervening into between the boundary faces of the iron particles 2 while partially covering the surfaces of the iron particles 2. The coppers 3 gather most in the vicinity of the contact portions of the iron particles 2 (or the most adjacent portions of the same to one another). Such an adhesion gives the porous body a tensile strength approximately of the iron instead of that of the copper.

As shown in Fig. 7B, the porous bodies 10 according to the first embodiment are structured to have the coppers 3 intervening into the space 20 between the iron particles 2. The comparison of the space 20 in Fig. 7B with a space 30 in Fig. 7A indicates that the space 20 has protruding and recessed portions 3a formed by the copper 3, and protruding and recessed portions 3b formed by the copper 3 and the surfaces of the iron particles 2. Hence, it is easily found that the surface area of the space 20 is larger than the surface area of the space 30 having no protruding and recessed portions 3a, 3b.

In addition, in such a porous body 10 that makes use of the space between the iron particles 2 as an air hole, by increasing a surface area to volume ratio of the space, it is possible to improve the capability to cool a gas passing through the porous body. Further, with the increase in the surface area of the space, it is also possible to improve the capability to trap coarse particles and the like included in the porous body (dust collection capability). Similarly, the capability to deaden sound is improved. Furthermore, the production of the porous body 10, which is formed by firmly welding the iron particles 2 to one another with the copper 3, allows to produce the porous body 10 with higher pressure resistance at lower cost as compared to the porous body formed by sintering merely the iron particles 2 by a solid-phase diffusion.

(Second embodiment)

Next, a second embodiment of the present invention will be described.

As with the first embodiment, the base particle composing a porous body and an adhesion material for causing the base particles to adhere to one another are iron particles 2 and copper 3, respectively. Differently from the first embodiment, in the second embodiment, a porous body 60 (refer to Fig. 12) which is produced by coating the iron particles 2 with the copper 3 by plating before performing the heating and cooling, and the method for producing the same are provided. Note that, other than the copper 3 itself, a material which is in a liquid state at a room temperature and includes copper such as copper alkoxide or copper acetate (monohydrate or anhydrous) dissolved in an ethanol and a 2-methoxyethanol can also be used as a material for the coating. Further, the copper 3 may be bonded to the iron particles 2 by a thermal spraying or a sputtering of the copper 3 to the iron particles 2. Incidentally, the same numeral signals are used for the same parts as in the first embodiment.

Firstly, based on Fig. 9, a production process of the porous body 60 in the second embodiment will be described.

The production process of the porous body 60 is carried out in order of a coating step (step S201) for coating the iron particles 2 with the copper 3 by plating (a kind of coatings), an inputting step (step S202) for inputting coated particles (hereinafter referred to as "composite particles") 50 obtained by the coating step into a container 51 for forming a flat plate, a heating step (step S203) for heating the container 51 having the composite particles 50 therein, a cooling step (step S204) following the heating.

It should be noted that the coating may be performed in the container 51 for forming a flat plate after inputting the iron particles 2 and the copper powders 3 thereinto. For instance, it is possible to input the iron particles 2 and the copper powders 3 into the container 51 for forming a flat plate to produce the composite particles 50 with the copper powders 3 being sprinkled on the

surfaces of the iron particles 2 by oscillating the container 51 so that the heating is performed directly to the container 51. In that case, step S201 and step S202 are counterchanged.

As shown in Fig. 8, the composite particles 50 are heated in a heating furnace 4 in a state still inputted into the container 51 for forming a flat plate. The heating step (step S203) is performed by moving the container 51 for forming a flat plate toward the outlet from the inlet of the heating furnace 4 using the belt conveyer 5 as in the case of the first embodiment.

A composite particle 50a shown in Fig. 10A is the iron particle 2 completely coated with the copper 3 and having protruding and recessed portions formed on the surface thereof. Both the composite particles 50b, 50c respectively shown in Fig. 10B and Fig. 10C are the iron particles 2 with the copper 3 bonded partially to the surfaces thereof, having the protruding and recessed portions formed by the surfaces of the iron particles 2 and the coppers 3. Such composite particles 50 can be produced variously in accordance with various conditions such as the size of the copper 3 relative to the iron particle 2, properties of the copper 3, a coating time, and the like.

For instance, a longer coating time has a tendency to produce a particle represented by the iron particle 2 having the copper 3 all over the surface thereof as with the composite particle 50a. Meanwhile, a shorter coating time has a tendency to produce a particle represented by the iron particle 2 having the copper bonded to the surface in a sprinkled manner as with the composite particle 50c. An intermediate coating time between the former and the latter coating times has a tendency to produce a particle represented by the iron particle 2 having the copper partially bonded on the surface thereof as with the composite particle 50b. However, the bonded state of the copper changes depending largely on the kind of solvents and the like used in addition to the coating time.

In addition, when using the copper powder 3 themselves for directly coating the iron particles 2, a wet copper powder 3 tends to form such a particle as denoted by 50a, and a dried copper powder 3 tends to form such a particle as denoted by 50c. Further, when the copper powder 3 is relatively smaller than the iron particle 2 in size, such a particle as denoted by 50a tends to be produced. On the other hand, when the copper powder 3 is relatively larger than the iron particle 2 in size, such a particle as denoted by 50c tends to be produced.

Furthermore, in general, the pattern of the composite particle largely depends also on wettability of the adhesion material with regard to the surface of the base particle, as is similarly applicable to iron and copper as a combination of the materials. With higher moisture-absorption characteristics, such a particle shown as the composite particle 50a having the adhesion material bonded all over the surface thereof tends to be formed. While, with a lower moisture-absorption characteristics, such a particle shown as the composite particle 50b or the composite particle 50c having the adhesion material partially bonded to the surface thereof tends to be produced.

As shown in Fig. 11, when the composite particles 50c are heated, the copper 3 or the copper powders 3 melts down to form island-shaped patterns, and that many of them move into the contact portions or the most adjacent portions of the iron particles 2 themselves. As a result, the composite particles 50c are bonded by having therebetween the coppers 3 in the vicinity of the contact portions of the iron particles 2. Accordingly, in the space between the iron particles 2, there exist a number of fine coppers 3. Consequently, the porous body 60 of such a structure comes to show excellent performances of cooling a gas passing through the spaces thereof and of collecting dusts to trap coarse particles or the like contained in the gas. Moreover, the porous body 60 also show a increased performance of deadening sound.

The porous body 60 of a flat-plate shape shown in Fig. 12 can be used as it is as a flat plate, whereas, it can also be used as a cylindrical porous body 60 by being cylindrically rolled up. In this case, it is preferable to perform a cylindrical shape forming step (step S205) to form the porous body 60 of a flat-plate shape into a sylindrical shape following the cooling step (step S204) in the flowchart in Fig. 9. The cylindrical shape forming step may be performed between the heating step (step S203) and the cooling step (step S204) in the flowchart in Fig. 9. Incidentally, the cylindrical shape forming step (step S205) may be a step to form the porous body 60 of a flat-plate shape into the cylindrical shape having a polygonal shape on the outer periphery thereof.

As described above, when the porous body 60 is produced with the coated composite particles 50, the adhesion of the coppers 3 to the iron particles 2 is ensured, whereby the strength of the porous body 60 comes to stable. Besides, the composite particles 5 are user friendly, so that the operation for producing the porous body 60 is facilitated.

Although the first embodiment and the second embodiment of the present invention have been described in the above, the present invention is not intended to be limited to the above-described embodiments and may be embodied in other specific forms being diversely varied without departing from the spirit or essential characteristics thereof.

For instance, in the first embodiment, the coated composite particles 50 (for example by plating) shown in the second embodiment may be inputted into the container 1 instead of inputting the mixture of liquid copper brazing material and iron particles 2. On the other hand, it is also acceptable to pour the mixture of the liquid copper brazing material and the iron particles 2 into the container 51 for forming a flat plate.

Moreover, in the case of the second embodiment, the other method for coating the iron particles 2 with the copper 3 may also be adopted in addition to

the plating of the copper 3 over the iron particles 2. Fig. 13 is a view showing a sputter coating apparatus for coating the iron particles 2 with the copper 3 by an ion beam sputter deposition method. This sputter coating apparatus 70 is provided with a target fixing platform 80, a target 81 made of copper to be fixed to the target fixing platform 80, a rotatable netted container 82, and a rotating shaft 83 to be connected to a drive source (for example, a motor) for rotating the netted container 82.

When argon ions are radiated from not-shown ion gun to the target 81, copper atoms (denoted by "Cu" in the drawing) are pushed out from the target 81. As a result, the coppers 3 coat the iron particles 2 inputted in the netted container 82 rotating above the target 81. The iron particles 2 in the netted container 82 are agitated within the netted container 82, so that the coating of the coppers 3 is carried out equally over the iron particles 2. Incidentally, a method for bonding the coppers 3 to the iron particles 2 by a thermal spraying may be adopted instead of such a sputtering method.

(Third embodiment)

Subsequently, a third embodiment of the present invention will be described. As with the first embodiment, base particles composing a porous body and an adhesion material for causing the base particles to adhere to one another are iron particles 2 and copper 3, respectively.

A heating unit 100 shown in Fig. 14 is provided with a furnace 101 and a passage 102 for introducing a sample into inside the furnace 101, a passage 103 for moving the sample in the furnace 101, a passage 104 for discharging the sample outside the furnace 101, a power output section 105 for moving the sample to the passage 102, the passage 103, and the passage 104, and a control board 106 for controlling conditions represented by a heating temperature of the sample, a moving amount of the sample, an amount of reducing gas, and the like.

Inside the furnace 101, there is a heating zone 107 having a build-in heater therein. Also, into the furnace 101, a thermocouple 108 and a thermocouple 109 are inserted. By measuring the temperature of the heating zone 107 with the thermocouples 108, 109, the heating temperature or a temperature distribution inside the furnace 101 is controlled. The area of the passage 102 is an area for preheating the sample. The area of the passage 103 existing inside the furnace 101 is an area for heating the sample. The areas of the passages 103, 104 existing outside the furnace 101 are areas for cooling the sample. Further, the power output section 105 is provided with a pulley 110, a pulley 111, and a belt 112 strained over the pulleys 110, 111. This belt 112 is disposed from the pulley 110 to the pulley 111 and the pulley 110 via each bottom portion of the passage 102, the passage 103, and the passage 104 so that they are connected. The pulley 110 is interlocked with a rotor plate 113a of a motor 113 via the belt 114. Accordingly, by rotating the motor 113, the belt 112 is activated by the rotation of the pulley 110.

On the inlet side of the passage 102, there is an opennable and closable door 115 for inputting the sample from the passage 102. This door 115 is driven to move in the vertical direction by a door opening/closing apparatus 116. Similarly, on the outlet side of the passage 104, there are an opennable and closable door 117 and a door opening/closing apparatus 118 for driving the door move in the vertical direction.

A container 120, which has iron particles 2 therein as a sample, goes up from the door 115 through the passage 102 to enter into the furnace 101 while being preheated, after it is placed outside the door 115, following that, the door 115 is opened, and the belt 112 is placed inside the furnace 101 to move in the right direction in Fig. 14. The container 120 is heated while moving through the passage 103 in the furnace 101 to be discharged outside the furnace 101. After that, the container 120 is cooled while moving through the passage 103

and the passage 104. The cooled container 120 is delivered from the opened door 117 to the outside.

The furnace 101 is further provided with a gas introduction pipe 121 and a gas exhaust pipe 122. One end of the gas introduction pipe 121, which is opposite to the furnace 101, is connected to a gas cylinder 123 filled with a reducing gas. When the iron particles 2 in the container 120 are introduced into inside the furnace 101, the reducing gas is sent from the gas cylinder 123 to the furnace 101. The iron particles 2 are therefore heated under the reducing atmosphere gas. Accordingly, iron oxides existing on the surfaces of the iron particles 2 are resolved by the reducing gas. In the present embodiment, as a reducing gas, a hydrogen gas being suitable for resolving the iron oxides is used.

Subsequently, a method for producing the porous body according to the third embodiment of the present invention will be described based on a flowchart shown in Fig. 15.

Firstly, the iron particles 2 being base particles are inputted into the container 120 (step S301) and heated in the heating unit 100 shown in Fig. 14 under a hydrogen gas atmosphere (step S302). After being discharged from the furnace 101, the container 120 further moves through the passage 103 to reach the outlet of the passage 104 while being cooled down (step S303). The resultant iron particles 2 after the cooling are particles without oxides such as iron oxides and the like which have been eliminated by the hydrogen gas. Next, the iron particles 2 are brazed with copper 3 in paste form on their surfaces (step S304). Then, the brazed iron particles 2 are again inputted into the heating unit 100 (step S305). Incidentally, the container used in step S305 is the same container as used in step S301 here, but the other container is allowed. The container 120 having the brazed iron particles 2 therein is heated in the heating area in the heating unit 100 (step S306) and discharged from the

furnace 101 to move further through the passage 103 to reach the outlet of the passage 104 while being cooled down (step S307). As stated above, a porous body with its spaces between the iron particles 2 being welded with the copper 3 is produced.

Incidentally, when a container for producing a porous body of a thin-plate shape is used as a container 120, preferably, a cylindrical shape forming step to form the porous body into a clyndrical shape is performed (step S308) following step S307. Additionally, the cylindrical shape forming step may be performed between the heating step (step S306) and the cooling step (step S307) of the flow in Fig. 15. Moreover, the cylindrical shape forming step (step S308) may be a step to shape the porous body of a flat-plate shape into a cylindrical shape having a polygonal shape on the outer periphery thereof.

Further, the combination of the base particle and the adhesion material is not limited to the iron and copper. As a base particle, other than the iron, various materials are applicable such as a carbon steel, an alloy steel, a cemented carbide, a stainless steel, a nickel, copper, copper alloy, a titanium, a titanium alloy, an aluminum, an aluminum alloy, gold, a platinum, a heat-resistant metal, a ceramic, a diamond, and the like. Meanwhile, as an adhesion material, various materials can be adopted such as copper, a nickel, a silver, a gold, a phosphor copper, a titanium, an aluminum, an active metals, and the like, provided that the adhesion material fuses better than the base particle, as previously stated.

Consequently, as a combination of the base particle and the adhesion material, the following combinations are appropriate: the combination of the iron, the copper, the nickel, or the cemented carbide as a base particle, and the silver brazing material as an adhesion material; the combination of the platinum or the stainless steel as a base particle, and the gold brazing material as an adhesion material; the combination of the iron, the stainless steel, or the

cemented carbide as a base particle, and the copper brazing material as an adhesion material; the combination of the copper or the copper alloy as a base particle, and the phosphor copper brazing material as an adhesion material; the combination of the titanium alloy as a base particle, and the titanium brazing material as an adhesion material; the combination of the stainless steel or the heat-resistant metal as a base particle, and the nickel brazing material as an adhesion material; the combination of the ceramic or the diamond as a base particle, and the active metal brazing material as an adhesion material; and the combination of the aluminum alloy as a base particle, and the aluminum brazing material as an adhesion material.

It should be noted that if the adhesion material is a refined particle minuter than the base particle, the same material can be used for both the base particle and the adhesion material. For instance, the combination of the gold as a base particle and the gold as an adhesion material, the combination of the titanium as a base particle and the titanium as an adhesion material, or the combination of the aluminum as a base particle and the alminum as an adhesion material is acceptable. Such a combination of the same materials is allowed since the minuter material, among the same materials, melts swifter than the other material when heated.

Further, although the hydrogen is used as a reducing gas when resolving the iron oxide, the other reducing gas other than the hydrogen gas may be used when resolving the oxides on the surfaces of the base particles of the other kinds. For instance, when the titanium is used as a base particle, not hydrogen but nitrogen or the like is more preferable. As mentioned above, preferably, the kind of the reducing gas is determined in accordance with the kind of the base particle and, if possible, the adhesion material as well.

Furthermore, in the above-described embodiments, as a base particle and an adhesion material, metals are used, and the base particle is welded with

the adhesion material. However, for performing not the welding but an adhering of a superordinate concept, as a base particle, the ceramic can be used in combination with the metal as an adhesion material. Moreover, it is also allowed to use the metal or the ceramic as a base particle in combination with resin as an adhesion material. Additionally, the ceramic may be used for both the base particle and the adhesion material.

INDUSTRIAL AVAILABILITY

In addition to the above, the porous body of the present invention is applicable to a filter which makes use of its spaces between the base particles as air holes or water permeable holes. Further, the porous body of the present invention is also applicable as an absorbent material or a sound-deadening material. Specifically, the porous body of the present invention is applicable to the sound-deadening material to be disposed in a muffler unit of a vehicle, and various filters such as a cooling filter for the vehicle, a filter for a lauter tub, a filter for a clean room, and so forth. Furthermore, the porous body of the present invention exhibits higher pressure resistance performance, so that it is also suitable for the filter for an airbag unit of the vehicle.